2. General Description of System

a. Figure 1 is a simplified block diagram of the proposed receiving system. The input to the system is amplified by a common broadband radio-frequency amplifier covering the frequency range of 50-to-300 mc. The amplified output is applied to several sub-band converters. In the system configuration shown in figure 1, full band coverage is obtained with three sub-band converters covering the range of 50 to 90 mc, 90 to 160 mc, and 160 to 300 mc, respectively. The reasons for splitting the band coverage in this manner are discussed in Section 3 of this proposal; the basic reason is to minimize spurious responses. The sub-band converters are nearly identical component-wise, and differ only in the frequency coverage provided. Each sub-band converter contains the necessary input and output filters, an r-f buffer amplifier, an i-f output amplifier, a broadband mixer, a crystal oscillator/multiplier, and a counter matrix for switching the crystals and providing a digital indication of the frequency.

b. The output of each sub-band converter, centered about 400 mc, is applied to its corresponding fine-tuning receiving/detection unit. This unit has a bandwidth of ± 5 mc centered about 400 mc and thus accepts the complete 10-mc spectrum heterodyned by each of the switched crystals in the sub-band converter. After the signal is amplified and filtered in the 400-mc first i-f amplifier, it is mixed with the output of another crystal-controlled local oscillator to obtain a 10-mc band of signals centered about 17.5 mc. Then, after this 10-mc band of signals is amplified by the second i-f amplifier, it is applied to a wide-band mixer where another conversion process takes place. The output of the second i-f amplifier is heterodyned with the output of an oscillator whose frequency is digitally shifted from 60 mc to 70 mc in 500-kc increments. The resulting signal, which has a 500-kc bandwidth centered about 47.5 mc, is applied to the

third i-f amplifier. After amplification, the signal is subjected to post-detection processing which includes AM, FM, and synchronous detection of the signals as well as AGC, threshold, and sweep/lock-on action.

c. The circuits associated with AM detection, FM detection, c-w thresholds, AGC circuits, audio/video amplifiers, and the sweep/lock-on action will be completely transistorized insofar as practicable. These circuits will perform the same functions as those of the corresponding circuits in Band 1 equipment. The circuits associated with the coherent or synchronous detection function will be completely new. As discussed in detail in Section 3, they will consist of means to provide for phase lock of a narrow-band signal. The bandwidth of the locking circuit, as well as the threshold circuit itself, will permit an extension of threshold capabilities (with respect to the i-f signal-to-noise ratio) by approximately 10 db over what now exists for the Band 1 receiving equipment.

d. Each sub-band converter with its associated fine-tuning receiving/detection unit provides a completely independent receiving unit whose functional operation is as follows: Coarse scanning (in 10-mc increments) is provided in each sub-band converter by switching crystals in the oscillator circuit. The number of crystals varies from four for the low-frequency sub-band to 14 for the high-frequency sub-band. During the interval a particular crystal is gated on, its associated 10-mc band is scanned in 500-kc increments. In most cases, either the pulse or c-w threshold circuit associated with the fine-tuning receiving/detection unit has provisions for stopping the sweeping process when the threshold level is exceeded.

e. If desired, the sweep could be sufficiently rapid that the dwell-time on any one frequency would be only long enough to settle the half-megacycle bandwidth. However, since many radars of low prf are of interest in these frequency ranges, the

dwell-time on each quantum frequency step should be on the order of 10 ms. The 10-ms dwell will permit a search and location of narrow-band c-w signals by the synchronous system, which has an effective bandwidth of 10 kc. At the conclusion of the 10 ms, if lock-on action has been initiated by a threshold signal from either the regular AM channel or the threshold circuits associated with the synchronous phase-lock channel, sweeping will be halted. If the phase-lock circuits are actuated, they will act within the first second of the lock-on to achieve an accurate phase lock. Upon termination of lock-on, as indicated by the timing device within the lock-on logic, the frequency stepping in the fine-tuning receiving/detection unit is resumed and the locking-scanning procedure is continued until the entire 10 mc is covered. Then, the next first-local-oscillator crystal in the sub-band converter unit is gated on, advancing the frequency by 10 mc. Fine step-scanning in the sub-band converter unit is continued in this fashion until the upper frequency limit of the sub-band is reached. Then, the scanning process is repeated, starting from the lower frequency limit of the sub-band. If a switching antenna system is used, a particular crystal in the sub-band converter unit is switched only after the fine-tuning receiving/detection unit has serviced both antenna stations.

3. Detailed Description of System

a. Sub-Band Converters

(1) The proposed heterodyning method for this receiving system is selected to minimize the spurious response problems for wide-band r-f inputs. The basic heterodyning process -- where the first i-f frequency is above the highest frequency in the r-f bandwidth, and the local-oscillator frequency is above the first i-f frequency -- completely eliminates the basic image problem, even in a band as wide as 50 to 300 mc.

(2) As is well known, all wide-band mixers suffer from certain spurious-frequency-response problems. These are a function of the non-linearities inherent in the mixing process. The most troublesome of these are those due to second-order effects of signals appearing in the basic input bandwidth.

(3) The severity of all of these kinds of spurious responses are, for most practical types of mixers, a function of the injection ratio; i.e., the ratio of the received signal power to the power applied to the mixer by the local oscillator. Indeed, as long as the injection ratio is considerably less than unity, the order of interference is a direct function of this ratio. In other words, the smaller the injection ratio, the less the susceptibility to spurious-frequency responses.

(4) Figure 2 shows the more significant spurious-frequency responses implicit in a receiver covering the frequency range of 50 to 300 mc and having a first intermediate frequency of 400 mc. The most severe of the spurious responses are those due to second-order effects; i.e., the beats produced by the second harmonic of the spurious signal in conjunction with the local oscillator or some harmonic thereof. The third-order signals are also shown. As higher and higher orders of spurious response are considered, it would be observed that they would completely fill the entire band.